STATE OF CALIFORNIA—BUSINESS, TRANSPORTATION AND HOUSING AGENCY

DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Transportation Laboratory
5900 Folsom Boulevard
Sacramento, California 95819-4612

METHOD OF TESTING FOR SPECIFICATION COMPLIANCE OF NONREFLECTIVE AND REFLECTIVE PAVEMENT MARKERS

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Part 2 Section 8 of this method. It is the responsibility of whoever uses this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

SCOPE

The following methods in the two parts of this test describe the testing procedures to be used for determining specification compliance for nonreflective and reflective pavement markers.

The nonreflective pavement marker portion of this test method is divided into the following parts:

1. Identification and Workmanship
2. Bond Strength
3. Glaze Thickness
4. Hardness
5. Directional Reflectance
6. Index of Yellowness
7. Color
8. Autoclave
9. Strength by Compressive Loadings
10. Water Absorption

The reflective pavement marker portion of this test method is divided into the following parts:

1. Identification and Workmanship
2. Bond Strength
3. Strength by Compressive Loading
4. Water Soak Resistance
5. Color
6. Reflectance
7. Steel Wool Abrasion
8. Safety and Health

PART 1. NONREFLECTIVE PAVEMENT MARKERS

1. IDENTIFICATION AND WORKMANSHIP

Use visual inspection and appropriate measurements to determine if the markers are the type and have the color, shape, dimensions, tolerances, characteristic, and finish specified.

2. BOND STRENGTH

A. APPARATUS

1. Tensile testing machine with a capacity of at least 45 kN and a rate capability of 22 kN/min.

2. Bond strength test fixture as shown in Figure 1.

3. Supply of 51-mm diameter steel test plugs 55-mm long, sandblasted on one end, and with a threaded hole in the other end. A plug made from 6061 aluminum of the same dimensions may also be used.

4. Plastic gloves.

5. Paper cups, several sizes.

6. Supply of wooden tongue depressors.

7. Epoxy adhesive.

B. PROCEDURE

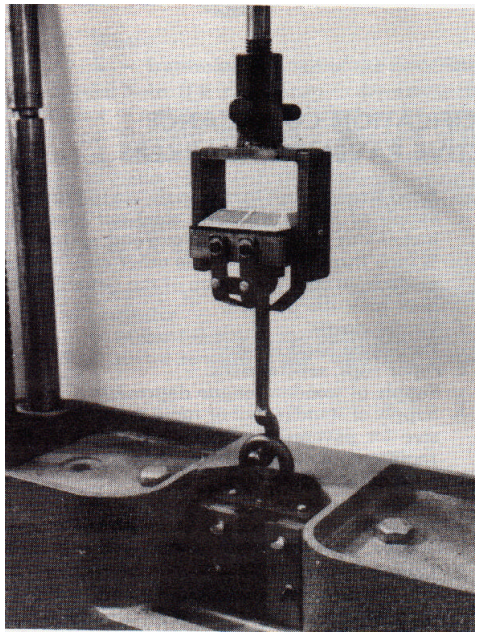
1. Condition test equipment, pavement markers, and adhesive at 21°C to 25°C for a minimum of four hours before testing.

2. Place a small amount of epoxy adhesive on the center of the bottom surface of the marker, and spread over an area approximately two inches in diameter. Place a thin layer of adhesive on the sandblasted surface of the plug and press down firmly onto the center of the bottom surface of the marker with a slight twisting motion. Using a tongue depressor with a squared end, carefully remove any adhesive which extrudes from under the plug. Cure the assembly for 48 hours at 21°C - 25°C.

3. At the end of the 48-hour curing period, determine the bond strength using the tensile testing machine. Use the bond strength test fixture shown in Figure 1. The fixture is designed to provide uniform load distribution and can be adapted to most standard test machines. A reflective marker is shown under test in Figure 1.

4. Report results in MPa:
Bond strength (MPa) = Total Force / Bond Area of Test Plug .

FIGURE 1



3. GLAZE THICKNESS

A. APPARATUS

1. Microscope of at least 25 power with a calibrated reticule.

2. Hammer.

3. Power sander.

4. Supply of Eriochrome Black T (black dye).

5. Hydrofluoric acid, 48 %, See Hazard in Part 2, Section 8.

B. PROCEDURE

1. Use hammer to break pavement marker into fragments small enough to be viewed under a compound microscope and select a fragment, preferably wedge shaped with a tapered edge, for test. The area selected for measurement must be at least 6 millimeters from the edge of marker. Grind the glazed tapered edge smooth and flat using a power sander with fine textured abrasive belt. In most cases the edges of the glaze will then be clearly delineated when viewed through the

microscope, and no further preparation of the specimen will be necessary. When the glaze is not sharply defined, or for referee method purposes, use the following procedure to prepare the specimen for test.

2. Etch the area which has been ground smooth and flat with hydrofluoric acid for approximately thirty seconds. Wash thoroughly and dry. Apply a drop of Eriochrome Black T (black dye) to the etched surface; let stand for ten seconds and wipe off the excess stain. The body of the marker will absorb the dye, leaving glaze unmarked and well defined.

3. Mount specimen under microscope and measure glaze thickness with calibrated reticule using a minimum magnification of twenty-five. Proper lighting is important.

4. HARDNESS

A. APPARATUS

1. Shore "D" hardness durometer.

2. Moh's scale of relative hardness pencils, #6 orthoclase.

B. PROCEDURE

1. Shore "D" Hardness: Test in accordance with ASTM D 2240. Be careful to prepare a flat, smooth surface on each specimen to be tested. This may be accomplished using a belt sander, surface grinder, vertical mill or other suitable equipment. Record the initial maximum reading as the hardness.

2. Moh Hardness: Determine the Moh hardness of the glazed surface of the marker relative to the mineral orthoclase, which has a hardness of 6. Using moderate hand pressure, it must not be possible to scratch the glazed surface of the marker with orthoclase.

5. DIRECTIONAL REFLECTANCE

Test the top of the convex glazed surface of the pavement markers in accordance with ASTM E 97.

6. INDEX OF YELLOWNESS

Test the glazed surface and the body of the marker in accordance with ASTM E 313. Determine the index of yellowness for the body of the marker on a smooth, flat, clean surface. The index of yellowness may be determined on the bottom surface of the marker. Those markers that fail the specification requirement shall be further tested by sawing the marker into two pieces. The index of yellowness shall be measured on the sawed side of the marker through a 12.7-mm aperture.

7. COLOR

Make chromaticity measurements in accordance with California Test 660.

8. AUTOCLAVE

Test in accordance with ASTM C 424 with the following exception. Subject the specimens to only one autoclave cycle at 0.69 MPa for one hour. Use slow pressure release.

9. STRENGTH BY COMPRESSIVE LOADING

A. APPARATUS

1. Compression testing machine with a capacity of at least 22 kN and a rate capability of 5-mm per minute.

2. Steel ring, 25-mm high, 75-mm internal diameter and a 6-mm wall.

3. Solid metal plug, 25.4 mm in diameter and 25-mm high.

4. Protective eye glasses or shield.

5. High strength casting plaster or sulfur mortar compound (ASTM C 617).

B. PROCEDURE

1. A high-strength casting plaster with a minimum rated strength of 18 kN shall be used to fill the voids between the protrusions on the bottom of the marker. The casting plaster shall be mixed with sufficient water to be fluid enough that the protrusions will easily penetrate through to the forming level plate. Allow adequate time for the casting plaster to set. Moderate oven temperature of 55°C may be utilized to speed drying time.

    a. An alternate method of filling voids can be the use of a sulfur mortar compound and plates as designated in ASTM C 617.

    NOTE: Use extreme caution when using sulfur mortar compound as the usable temperature is between 120°C and 150°C. Always use long gauntlet leather gloves when handling melted compound.

2. Place the steel ring in the testing machine and center the marker base down upon the ring.

3. Center the solid metal plug on top of the marker.

4. At a rate of 5-mm per minute, apply the load necessary to break the marker. Use protective eye glasses or shield.

5. Record the strength by compressive loading in kN.

10. WATER ABSORPTION

Test in accordance with ASTM C 373 with the following exception. Specimens selected for the water absorption test shall be whole markers and the glaze shall not be removed.

PART 2. REFLECTIVE PAVEMENT MARKERS

1. IDENTIFICATION AND WORKMANSHIP

Same as Part 1.

2. BOND STRENGTH

Same as Part 1.

3. STRENGTH BY COMPRESSIVE LOADING

A. APPARATUS

Same as Part 1, Section 9.

B. PROCEDURE

Same as Part 1, Section 9. In addition to the 8.9 kN minimum load specified in the California Standard Specifications, failure of a marker shall also consist of, (1) significant deformation of the marker at a load of less than 8.9 kN or, (2) significant delamination of the shell and the filler material regardless of the load required to break the marker.

NOTE: Significant deformation or delamination shall normally consist of more than 3.2 mm.

4. WATER SOAK RESISTANCE

Immerse pavement markers in water, maintained at (35° ± 3°C) for 48 hours. Then remove from water and immediately examine the marker for any delamination or loss of reflectance as determined in accordance with the following Section 6, “Reflectance”.

5. COLOR

Use visual comparison with a previously approved reference marker to determine that the color(s) of the reflectors when illuminated are as specified.

6. REFLECTANCE

A. APPARATUS

1. Reflex photometer with power supply, output meter, appropriate color filters, goniometer, pavement marker mount, and miscellaneous fixtures, as needed.

2. Reference reflective pavement marker to determine the specific intensity of the reference reflective marker, see the calibration procedure in Sections A and B of the following procedure.

B. PROCEDURE

1. Remove the reference marker to be used from its protective storage and place it in the photometer on the pavement marker fixture at the 1.52-meter test distance and 0˚ entrance angle.

2. Set the output meter to approximately the specific intensity of the reference marker.

3. Remove reference marker and push Relative button "on". Replace reference marker and using the rear (nearest to the light source) adjustable iris, set the output meter to the reading indicated on marker. Remove and replace reference marker a few times to check placement and meter settings. The meter will now indicate the specific intensity of the markers to be tested as a direct reading.

A. Reference reflective marker calibration procedure (Clear Reflector).

    1. Open both irises to full open position.

    2. Set the marker fixture aside and, leaving all settings as is, remove the photocell assembly from its normal position near the lamp end of the Photometer and mount it on the goniometer at the 1.52-meter distance, 0˚ entrance angle, using the fixture supplied for this purpose. Record the meter reading.

    3. Return the photocell to its normal position, remove the goniometer and replace the marker fixture, leaving the lamp settings as is.

    4. Push the Reference button "on". The meter should now read zero. Place the marker on the fixture and record the reading. Calculate the specific intensity (S_x) of the marker using the equation:

$$S_x = (R/C)\,D^2$$

Where:

R = meter reading of the reflector

C = meter reading of the photocell

D = test distance

B. Reference reflective marker calibration procedure (Color Reflector)

    1. Follow the same procedure outlined in Calibration Procedure (Clear Reflector) (Section A) with the following exceptions:

        a. In paragraph 2, place a filter of the proper color in front of the photocell.

        b. In paragraph 4, if the reflector and the photocell are read at the same distance (D) the specific intensity (S_x) is calculated using the equation:

$$S_x = (R/C)\,D^2K$$

Where:

K = Transmission Factor of the color filter.

C. Special Note: If it is necessary to determine the reflectance of a single or several markers for which there is no "Standard" available, a "Standard" of approximately the same size and specific intensity can be used in conjunction with

the following equation and previously discussed procedures to calculate the unknown markers' specific intensity (S_x):

$$S_x = S_r (X/R)$$

Where:

S_r = known specific intensity of the "Standard' reflector.

X = meter reading of the unknown reflector

R = meter reading of the "Standard" reflector.

7. STEEL WOOL ABRASION PROCEDURE

When required for reflective markers to be installed as recessed pavement markers this procedure shall be performed prior to Section 6 "Reflectance".

A. APPARATUS

1. Number 3 course steel wool per Federal Specification FF-W-1825

B. PROCEDURE

Form a 25-mm diameter flat pad with the steel wool. Place the steel wool pad on the reflector lens. Apply a load of 22 kg and rub the entire lens surface 100 times.

NOTE: On two color units the red lens may not be abrasion resistant and if so should not be abraded.

8. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans' Laboratory Safety Manual.

Hazards: Hydrofluoric acid is highly poisonous. It is highly irritating to the skin (a burn might not be visible or painful immediately) and the respiratory tract (a recommended TLV of 2.6 mg/m^3). Read the directions and precautions on the label before using. Wear protective clothing and equipment. Store in a cool, ventilated location. Hydrofluoric acid will react with water or steam to produce poisonous and corrosive fumes.

REFERENCES:

ASTM Designation: C 617
ASTM Designation: C 373
ASTM Designation: C 424
ASTM Designation: D 2240
ASTM Designation: E 97
ASTM Designation: E 313
California Test 660
Federal Specification FF-W-1825

End of Test (California Test 669 contains 6 pages)